SCIENCE

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*CONTENTS:*



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## *ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

### THE INFLUENCE OF BRAIN-POWER ON HISTORY.

MY first duty to-night is a sad one. I have to refer to a great loss which this Nation and this Association have sustained. By the death of the great Englishman and great statesman who has just passed away, we members of the British Association are deprived of one of the most illustrious of our confrères. We have to mourn the loss of an enthusiastic student of science who conferred honor on our body by becoming its President. We recognize that as Prime Minister he was mindful of the interests of science, and that to him we owe a more general recognition on the part of the State of the value to the nation of the work of scientific men. On all these grounds you will join in the expression of respectful sympathy with Lord Salisbury's family in their great personal loss which your council has embodied this morning in a resolution of condolence.

Last year, when this friend of science ceased to be Prime Minister, he was succeeded by another statesman who also has given many proofs of his devotion to philosophical studies, and has shown in many utterances that he has a clear understanding of the real place of science in modern civilization. We then have good grounds

for hoping that the improvement in the position of science in this country which we owe to the one will also be the care of his successor, who has honored the Association by accepting the unanimous nomination of your council to be your President next year, an acceptance which adds a new lustre to this chair.

On this we may congratulate ourselves all the more because I think, although it is not generally recognized, that the century into which we have now well entered may be more momentous than any which has preceded it, and that the present history of the world is being so largely moulded by the influence of brain-power, which in these modern days has to do with natural as well as human forces and laws, that statesmen and politicians will have in the future to pay more regard to education and science, as empire-builders and empire-guarders, than they have paid in the past.

The nineteenth century will ever be known as the one in which the influences of science were first fully realized in civilized communities; the scientific progress was so gigantic that it seems rash to predict that any of its successors can be more important in the life of any nation.

Disraeli, in 1873, referring to the progress up to that year, spoke as follows: "How much has happened in these fifty years—a period more remarkable than any, I will venture to say, in the annals of mankind. I am not thinking of the rise and fall of Empires, the change of dynasties, the establishment of Governments. I am thinking of those revolutions of science which have had much more effect than any political causes, which have changed the position and prospects of mankind more than all the conquests and all the codes and all the legislators that ever lived."*

* *Nature*, November 27, 1873, Vol. IX., p. 71.

The progress of science, indeed, brings in many considerations which are momentous in relation to the life of any limited community—any one nation. One of these considerations to which attention is now being greatly drawn is that a relative decline in national wealth derived from industries must follow relative neglect of scientific education.

It was the late Prince Consort who first emphasized this when he came here fresh from the University of Bonn. Hence the 'Prince Consort's Committee,' which led to the foundation of the College of Chemistry and afterwards of the Science and Art Department. From that time to this the warnings of our men of science have become louder and more urgent in each succeeding year. But this is not all; the commercial output of one country in one century as compared with another is not alone in question; the acquirement of the scientific spirit and a knowledge and utilization of the forces of Nature are very much further reaching in their effects on the progress and decline of nations than is generally imagined.

Britain in the middle of the last century was certainly the country which gained most by the advent of science, for she was then in full possession of those material gifts of Nature, coal and iron, the combined winning and utilization of which, in the production of machinery and in other ways, soon made her the richest country in the world, the seat and throne of invention and manufacture, as Mr Carnegie has called her. Being the great producers and exporters of all kinds of manufactured goods, we became eventually, with our iron ships, the great carriers, and hence the supremacy of our mercantile marine and our present command of the sea.

The most fundamental change wrought by the early applications of science was in

relation to producing and carrying power. With the winning of mineral wealth and the production of machinery in other countries, and cheap and rapid transit between nations, our superiority as depending upon first use of vast material resources was reduced. Science, which is above all things cosmopolitan—planetary, not national—internationalizes such resources at once. In every market of the world

> "things of beauty, things of use,
> Which one fair planet can produce,
> Brought from under every star,"

were soon to be found.

Hence the first great effect of the general progress of science was relatively to diminish the initial supremacy of Britain due to the first use of *material* resources, which indeed was the real source of our national wealth and place among the nations.

The unfortunate thing was that, while the foundations of our superiority depending upon our *material resources* were being thus sapped by a cause *which was beyond our control,* our statesmen and our universities were blind leaders of the blind, and our other asset, our mental resources, which was within our control, was culpably neglected.

So little did the bulk of our statesmen know of the part science was playing in the modern world and of the real basis of the nation's activities, that they imagined political and fiscal problems to be the only matters of importance. Nor, indeed, are we very much better off to-day. In the important discussions recently raised by Mr. Chamberlain, next to nothing has been said of the effect of the progress of science on prices. The whole course of the modern world is attributed to the presence or absence of taxes on certain commodities in certain countries. The fact that the great fall in the price of food-stuffs in England did not come till some thirty or forty years after the removal of the corn duty between 1847 and 1849 gives them no pause; for them new inventions, railways and steamships are negligible quantities; the vast increase in the world's wealth in free trade and protected countries alike comes merely according to them in response to some *political* shibboleth.

We now know, from what has occurred in other States, that if our Ministers had been more wise and our universities more numerous and efficient, our *mental resources* would have been developed by improvements in educational method, by the introduction of science into schools, and, more important than all the rest, by the teaching of science by experiment, observation and research, and not from books. It is because this was not done that we have fallen behind other nations in properly applying science to industry, so that our applications of science to industry are relatively less important than they were. But this is by no means all; we have lacked the strengthening of the national life produced by fostering the scientific spirit among all classes, and along all lines of the nation's activity; many of the responsible authorities know little and care less about science; we have not learned that it is the duty of a State to organize its forces as carefully for peace as for war; that universities and other teaching centres are as important as battleships or big battalions; are, in fact, essential parts of a modern State's machinery, and as such to be equally aided and as efficiently organized to secure its future well being.

Now the objects of the British Association as laid down by its founders seventy-two years ago are "To give a stronger impulse and a more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers—to obtain a more general attention to the ob-

jects of science and a removal of any disadvantages of a public kind which impede its progress.''

In the main, my predecessors in this chair, to which you have done me the honor to call me, have dealt, and with great benefit to science, with the objects first named.

But at a critical time like the present I find it imperative to depart from the course so generally followed by my predecessors and to deal with the last object named, for unless by some means or other we 'obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress,' we shall suffer in competition with other communities in which science is more generally utilized for the purposes of the national life.

### THE STRUGGLE FOR EXISTENCE IN MODERN COMMUNITIES.

Some years ago, in discussing the relations of scientific instruction to our industries, Huxley pointed out that we were in presence of a new 'struggle for existence,' a struggle which, once commenced must go on until only the fittest survives.

It is a struggle between organized species —nations—not between individuals or any class of individuals. It is, moreover, a struggle in which science and brains take the place of swords and sinews, on which depended the result of those conflicts which, up to the present, have determined the history and fate of nations. The school, the university, the laboratory and the workshop are the battlefields of this new warfare.

But it is evident that if this, or anything like it, be true, our industries can not be involved alone; the scientific spirit, brain-power, must not be limited to the workshop if other nations utilize it in all branches of their administration and executive.

It is a question of an important change of front. It is a question of finding a new basis of stability for the Empire in face of new conditions. I am certain that those familiar with the present states of things will acknowledge that the Prince of Wales's call, 'Wake up,' applies quite as much to the members of the Government as it does to the leaders of industry.

What is wanted is a complete organization of the resources of the nation, so as to enable it best to face all the new problems which the progress of science, combined with the ebb and flow of population and other factors in international competition, are ever bringing before us. Every Minister, every public department, is involved, and this being so, it is the duty of the whole nation—King, Lords, and Commons—to do what is necessary to place our scientific institutions on a proper footing in order to enable us to 'face the music' whatever the future may bring. The idea that science is useful only to our industries comes from want of thought. If anyone is under the impression that Britain is only suffering at present from the want of the scientific spirit among our industrial classes, and that those employed in the State service possess adequate brain-power and grip of the conditions of the modern world into which science so largely enters, let him read the report of the Royal Commission on the War in South Africa. There he will see how the whole 'system' employed was, in Sir Henry Brackenbury's words applied to a part of it, '*unsuited to the requirements of an Army which is maintained to enable us to make war.*' Let him read also, in the address of the president of the Society of Chemical Industry what drastic steps had to be taken by Chambers of Commerce and 'a quarter of a million of working men' to get the Patent Law Amendment Act into proper shape, in spite of all the advisers and officials of the Board of Trade. Very

few people realize the immense number of scientific problems the solution of which is required for the State service. The nation itself is a gigantic workshop, and the more our rulers and legislators, administrators and executive officers possess the scientific spirit, the more the rule of thumb is replaced in the State service by scientific methods, the more able shall we be, thus armed at all points, to compete successfully with other countries along all lines of national as well as of commercial activity.

It is obvious that the power of a nation for war, in men and arms and ships, is one thing; its power in the peace struggles to which I have referred is another; in the latter, the source and standard of national efficiency are entirely changed. To meet war conditions, there must be equality or superiority in battleships and army corps. To meet the new peace conditions there must be equality or superiority in universities, scientific organization and everything which conduces to greater brain power.

### OUR INDUSTRIES ARE SUFFERING IN THE PRESENT INTERNATIONAL COMPETITION.

The present condition of the nation, so far as its industries are concerned, is as well known, not only to the Prime Minister, but to other political leaders in and out of the Cabinet, as it is to you and to me. Let me refer to two speeches delivered by Lord Rosebery and Mr. Chamberlain on two successive days in January, 1901:

Lord Rosebery spoke as follows:

"* * * The war I regard with apprehension is the war of trade which is unmistakably upon us. * * * When I look round me I cannot blind my eyes to the fact that so far we can predict anything of the twentieth century on which we have now entered, it is that it will be one of acutest international conflict in point of trade. We were the first nation of the modern world to discover that trade was an absolute necessity. For that we were nicknamed a nation of shopkeepers; but now every nation wishes to be a nation of shopkeepers, too, and I am bound to say that when we look at the character of some of these nations, and when we look at the intelligence of their preparations, we may well feel that it behooves us not to fear, but to gird up our loins in preparation for what is before us."

Mr. Chamberlain's views were stated in the following words:

"I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. * * * It is not too much to say that the existence of this country, as the great commercial nation, depends upon it. * * * It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals."

All this refers to our industries. We are not suffering because trade no longer follows the flag as in the old days, but because trade follows the brains, and our manufacturers are too apt to be careless in securing them. In one chemical establishment in Germany, 400 doctors of science, the best the universities there can turn out, have been employed at different times in late years. In the United States the most successful students in the higher teaching centers are snapped up the moment they have finished their course of training, and put into charge of large concerns, so that the idea has got abroad that youth is the password of success in American industry. It has been forgotten that the latest product of the highest scientific education must necessarily be young, and that it is the training and not the age

which determines his employment. In Britain, on the other hand, apprentices who can pay high premiums are too often preferred to those who are well educated, and the old rule-of-thumb processes are preferred to new developments—a conservatism too often depending upon the master's own want of knowledge.

I should not be doing my duty if I did not point out that the defeat of our industries one after another, concerning which both Lord Rosebery and Mr. Chamberlain express their anxiety, is by no means the only thing we have to consider. The matter is not one which concerns our industrial classes only, for knowledge must be pursued for its own sake, and since the full life of a nation with a constantly increasing complexity, not only of industrial, but of high national aims, depends upon the universal presence of the scientific spirit—in other words, brain power—our whole national life is involved.

THE NECESSITY FOR A BODY DEALING WITH THE ORGANIZATION OF SCIENCE.

The present awakening in relation to the nation's real needs is largely due to the warnings of men of science. But Mr. Balfour's terrible Manchester picture of our present educational condition * shows that the warning which has been going on now for more than fifty years has not been forcible enough; but if my contention that other reorganizations besides that of our education are needed is well founded, and if men of science are to act the part of good citizens in taking their share in endeavoring to bring about a better state of things, the question arises, has the neglect of their warnings so far been due to the way in which these have been given?

Lord Rosebery, in the address to a Chamber of Commerce from which I have already quoted, expressed his opinion that such bodies do not exercise so much influence as might be expected of them. But if commercial men do not use all the power their organization provides, do they not by having built up such an organization put us students of science to shame, who are still the most disorganized members of the community?

Here, in my opinion, we have the real reason why the scientific needs of the nation fail to command the attention either of the public or of successive governments. At present, appeals on this or on that behalf are the appeals of individuals; science has no collective voice on the larger national questions; there is no organized body which formulates her demands.

During many years it has been part of my duty to consider such matters, and I have been driven to the conclusion that our great crying need is to bring about an organization of men of science and all interested in science, similar to those which prove so effective in other branches of human activity. For the last few years I have dreamt of a Chamber, Guild, League, call it what you will, with a wide and large membership, which should give us what, in my opinion, is so urgently needed. Quite recently I sketched out such an organization, but what was my astonishment to find that I had been forestalled, and by the founders of the British Association!

THE BRITISH ASSOCIATION SUCH A BODY.

At the commencement of this address I pointed out that one of the objects of the Association, as stated by its founders, was 'to obtain a more general attention to the objects of science and a removal of any

* "The existing educational system of this country is chaotic, is ineffectual, is utterly behind the age, makes us the laughing-stock of every advanced nation in Europe and America, puts us behind, not only our American cousins, but the German and the Frenchman and the Italian."—*Times*, October 15, 1902.

disadvantages of a public kind which impede its progress.'

Everyone connected with the British Association from its beginning may be congratulated upon the magnificent way in which the other objects of the Association have been carried out, but as one familiar with the Association for the last forty years, I cannot but think that the object to which I have specially referred has been too much overshadowed by the work done in connection with the others.

A careful study of the early history of the Association leads me to the belief that the function I am now dwelling on was strongly in the minds of the founders; but be this as it may, let me point out how admirably the organization is framed to enable men of science to influence public opinion and so to bring pressure to bear upon Governments which follow public opinion. (1) Unlike all the other chief metropolitan societies, its outlook is not limited to any branch or branches of science. (2) We have a wide and numerous fellowship, including both the leaders and the lovers of science, in which all branches of science are and always have been included with the utmost catholicity—a condition which renders strong committees possible on any subject. (3) An annual meeting at a time when people can pay attention to the deliberations, and when the newspapers can print reports. (4) The possibility of beating up recruits and establishing local committees in different localities, even in the King's dominions beyond the seas, since the place of meeting changes from year to year, and is not limited to these islands.

We not only, then, have a scientific parliament competent to deal with all matters, including those of national importance, relating to science, but machinery for influencing all new councils and committees dealing with local matters, the functions of which are daily becoming more important.

The machinery might consist of our corresponding societies. We already have affiliated to us seventy societies with a membership of 25,000; were this number increased so as to include every scientific society in the Empire, metropolitan and provincial, we might eventually hope for a membership of half a million.

I am glad to know that the Council is fully alive to the importance of giving impetus to the work of the corresponding societies. During this year a committee was appointed to deal with the question; and later still, after this committee had reported, a conference was held between this committee and the corresponding societies committee to consider the suggestions made, some of which will be gathered from the following extract:

"In view of the increasing importance of science to the nation at large, your committee desire to call the attention of the council to the fact that in the corresponding societies the British Association has gathered in the various centres represented by these societies practically all the scientific activity of the provinces. The number of members and associates at present on the list of the corresponding societies approaches 25,000, and no organization is in existence anywhere in the country better adapted than the British Association for stimulating, encouraging and coordinating all the work being carried on by the seventy societies at present enrolled. Your committee are of opinion that further encouragement should be given to these societies and their individual working members by every means within the power of the association; and with the object of keeping the corresponding societies in more permanent touch with the Association they suggest that an official invitation on behalf of the Council be addressed to the societies through the corresponding societies committee asking them to appoint standing

British Association sub-committees, to be elected by themselves with the object of dealing with all those subjects of investigation common to their societies and to the British Association committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centers. * * *

"Your committee desire to lay special emphasis on the necessity for the extension of the scientific activity of the corresponding societies and the expert knowledge of many of their members in the direction of scientific education. They are of opinion that immense benefit would accrue to the country if the corresponding societies would keep this requirement especially in view with the object of securing adequate representation for scientific education on the Education Committees now being appointed under the new Act. The educational section of the Association having been but recently added, the corresponding societies have as yet not had much opportunity for taking part in this branch of the Association's work; and in view of the reorganization in education now going on all over the country your committee are of opinion that no more opportune time is likely to occur for the influence of scientific organizations to make itself felt as a real factor in national education. * * *"

I believe that if these suggestions or anything like them—for some better way may be found on inquiry—are accepted, great good of science throughout the Empire will come. Rest assured that sooner or later such a guild will be formed because it is needed. It is for you to say whether it shall be, or form part of, the British Association. We in this Empire certainly need to organize science as much as in Germany they find the need to organize a navy. The German Navy League, which has branches even in our Colonies, already has a membership of 630,000, and its income is nearly 20,000*l*. a year. A British Science League of 500,000 with a sixpenny subscription would give us 12,000*l*. a year, quite enough to begin with.

I for one believe that the British Association would be a vast gainer by such an expansion of one of its existing functions. Increased authority and prestige would follow its increased utility. The meetings would possess a new interest; there would be new subjects for reports; missionary work less needed than formerly would be replaced by efforts much more suited to the real wants of the time. This magnificent, strong and complicated organization would become a living force, working throughout the year, instead of practically lying idle, useless and rusting for 51 weeks out of the 52 so far as its close association with its members is concerned.

If this suggestion in any way commends itself to you, then when you begin your work in your sections or general committee see to it that a body is appointed to inquire how the thing can be done. Remember that the British Association will be as much weakened by the creation of a new body to do the work I have shown to have been in the minds of its founders as I believe it will be strengthened by becomong completely effective in every one of the directions they indicated, and for which effectiveness we their successors are indeed responsible. The time is appropriate for such a reinforcement of one of the wings of our organization, for we have recently included Education among our sections.

There is another matter I should like to see referred to the committee I have spoken of, if it please you to appoint it. The British Association, which as I have already pointed out is now the chief body in the Empire which deals with the totality of science, is, I believe, the only organiza-

tion of any consequence which is without a charter, and which has not His Majesty the King as patron.

THE FIRST WORK OF SUCH AN ORGANIZATION.

I suppose it is my duty after I have suggested the need of organization to tell you my personal opinion as to the matters where we suffer most in consequence of our lack of organization at the present time.

Our position as a nation, our success as merchants, are in peril chiefly—dealing with preventable causes—because of our lack of completely efficient universities, and our neglect of research. This research has a double end. A professor who is not learning can not teach properly or arouse enthusiasm in his students; while a student of any thing who is unfamiliar with research methods, and without that training which research brings, will not be in the best position to apply his knowledge in after life. From neglect of research comes imperfect education and a small output of new applications and new knowledge to reinvigorate our industries. From imperfect education comes the unconcern touching scientific matters, and the too frequent absence of the scientific spirit, in the nation generally from the court to the parish council.

I propose to deal as briefly as I can with each of these points.

UNIVERSITIES.

I have shown that so far as our industries are concerned, the cause of our failure has been run to earth; it is fully recognized that it arises from the insufficiency of our universities both in numbers and efficiency, so that not only our captains of industry, but those employed on the nation's work generally, do not secure a training similar to that afforded by other nations. No additional endowment of primary, secondary or technical instruction will mend matters. This is not merely the opinion of men of science; our great towns know it, our Ministers know it.

It is sufficient for me to quote Mr. Chamberlain:—

"It is not everyone who can, by any possibility, go forward into the higher spheres of education; but it is from those who do that we have to look for the men who, in the future, will carry high the flag of this country in commercial, scientific and economic competition with other nations. At the present moment, I believe there is nothing more important than to supply the deficiences which separate us from those with whom we are in the closest competition. In Germany, in America, in our own colony of Canada and in Australia, the higher education of the people has more support from the Government, is carried further, than it is here in the old country; and the result is that in every profession, in every industry, you find the places taken by men and by women who have had a university education. And I would like to see the time in this country when no man should have a chance for any occupation of the better kind, either in our factories, our workshops or our counting-houses, who could not show proof that, in the course of his university career, he had deserved the position that was offered to him. What is it that makes a country? Of course you may say, and you would be quite right, 'The general qualities of the people, their resolution, their intelligence, their pertinacity, and many other good qualities.' Yes; but that is not all, and it is not the main creative feature of a great nation. The greatness of a nation is made by its greatest men. It is those we want to educate. It is to those who are able to go, it may be, from the very lowest steps in the ladder, to men who are able to devote their

time to higher education, that we have to look to continue the position which we now occupy as, at all events, one of the greatest nations on the face of the earth. And, feeling as I do on these subjects, you will not be surprised if I say that I think the time is coming when Governments will give more attention to this matter, and perhaps find a little more money to forward its interests" (*Times*, November 6, 1902).

Our conception of a university has changed. University education is no longer regarded as the luxury of the rich which concerns only those who can afford to pay heavily for it. The Prime Minister in a recent speech, while properly pointing out that the collective effect of our public and secondary schools upon British character can not be overrated, frankly acknowledged that the boys of seventeen or eighteen who have to be educated in them 'do not care a farthing about the world they live in except in so far as it concerns the cricket-field or the football-field or the river.' On this ground they are not to be taught science, and hence, when they proceed to the university, their curriculum is limited to subjects which were better taught before the modern world existed, or even Galileo was born. But the science which these young gentlemen neglect, with the full approval of their teachers, on their way through the school and the university to politics, the Civil Service, or the management of commercial concerns, is now one of the great necessities of a nation, and our universities must become as much the insurers of the future progress as battleships are the insurers of the present power of States. In other words, university competition between States is now as potent as competition in building battleships, and it is on this ground that our university conditions become of the highest national concern and, therefore, have to be referred to here, and all the more because our industries are not alone in question.

WHY WE HAVE NOT MORE UNIVERSITIES.

Chief among the causes which have brought us to the terrible condition of inferiority as compared with other nations in which we find ourselves are our carelessness in the matter of education and our false notions of the limitations of State functions in relation to the conditions of modern civilization.

Time was when the Navy was largely a matter of private and local effort. William the Conqueror gave privileges to the Cinque Ports on the condition that they furnished fifty-two ships when wanted. In the time of Edward III., of 730 sail engaged in the siege of Calais, 705 were 'people's ships." All this has passed away; for our first line of defence we no longer depend on private and local effort.

Time was when not a penny was spent by the State on elementary education. Again, we no longer depend upon private and local effort. The navy and primary education are now recognized as properly calling upon the public for the necessary financial support. But when we pass from primary to university education, instead of State endowment we find State neglect; we are in a region where it is nobody's business to see that anything is done.

We in Great Britain have thirteen universities competing with 134 State and privately endowed in the United States and twenty-two State endowed in Germany. I leave other countries out of consideration for lack of time, and I omit all reference to higher institutions for technical training, of which Germany alone possesses nine of university rank, because they are less important; they instruct rather than educate, and our want is education. The German State gives to one university more than the British Government allows to all the

universities and university colleges in England, Ireland, Scotland, and Wales put together. These are the conditions which regulate the production of brain-power in the United States, Germany, and Britain respectively, and the excuse of the Government is that this is a matter for private effort. Do not our Ministers of State know that other civilized countries grant efficient State aid, and further, that private effort has provided in Great Britain less than 10 per cent. of the sum thus furnished in the United States in addition to State aid? Are they content that we should go under in the great struggle of the modern world because the Ministers of other States are wiser, and because the individual citizens of another country are more generous, than our own?

If we grant that there was some excuse for the State's neglect so long as the higher teaching dealt only with words, and books alone had to be provided (for the streets of London and Paris have been used as class rooms at a pinch), it must not be forgotten that during the last hundred years not only has knowledge been enormously increased, but things have replaced words, and fully equipped laboratories must take the place of books and class rooms if university training worthy of the name is to be provided. There is much more difference in size and kind between an old and new university than there is between the old caravel and a modern battleship, and the endowments must follow suit.

What are the facts relating to private endowment in this country? In spite of the munificence displayed by a small number of individuals in some localities, the truth must be spoken. In depending in our country upon this form of endowment, we are trusting to a broken reed. If we take the twelve English university colleges, the forerunners of universities unless we are to perish from lack of knowledge, we find that private effort during sixty years has found less than 4,000,000*l.*, that is, 2,000,000*l.* for buildings and 40,000*l.* a year income. This gives us an average of 166,000*l.* for buildings and 3,300*l.* for yearly income.

What is the scale of private effort we have to compete with in regard to the American universities?

In the United States, during the last few years, universities and colleges have received more than 40,000,000*l.* from this source alone; private effort supplied nearly 7,000,000*l.* in the years 1898–1900.

Next consider the amount of State aid to universities afforded in Germany. The buildings of the new University of Strassburg have already cost nearly a million; that is, about as much as has yet been found by private effort for buildings in Manchester, Liverpool, Birmingham, Bristol, Newcastle and Sheffield. The Government annual endowment of the same German university is more than 49,000*l.*

This is what private endowment does for us in England, against State endowment in Germany.

But the State does really concede the principle; its present contribution to our universities and colleges amounts to 155,600*l.* a year; no capital sum, however, is taken for buildings. The State endowment of the University of Berlin in 1891–2 amounted to 168,777*l.*

When, then, we consider the large endowments of university education both in the United States and Germany, it is obvious that State aid only can make any valid competition possible with either. The more we study the facts, the more statistics are gone into, the more do we find that we, to a large extent, lack both of the sources of endowment upon one or other or both of which other nations depend. We are between two stools, and the prospect is hopeless without some drastic changes. And first among these, if we intend to get out of the present slough of despond, must be

the giving up of the idea of relying upon private effort.

That we lose most where the State does least is known to Mr. Chamberlain, for in his speech, to which I have referred, on the University of Birmingham, he said: "As the importance of the aim we are pursuing becomes more and more impressed upon the minds of the people, we may find that we shall be more generously treated by the State."

Later still, on the occasion of a visit to University College School, Mr. Chamberlain spoke as follows:

"When we are spending, as we are, many millions—I think it is 13,000,000*l.*—a year on primary education, it certainly seems as if we might add a little more, even a few tens of thousands, to what we give to University and secondary education" (*Times*, November 6, 1902).

To compete on equal grounds with other nations we must have more universities. But this is not all—we want a far better endowment of all the existing ones, not forgetting better opportunities for research on the part of both professors and students. Another crying need is that of more professors and better pay. Another is the reduction of fees; they should be reduced to the level in those countries which are competing with us, to say, one-fifth of their present rates, so as to enable more students in the secondary and technical schools to complete their education.

In all these ways, facilities would be afforded for providing the highest instruction to a much greater number of students. At present there are almost as many *professors and instructors* in the universities and colleges of the United States as there are *day students* in the universities and colleges of the United Kingdom.

Men of science, our leaders of industry, and the chiefs of our political parties all agree that our present want of higher education—in other words, properly equipped universities—is heavily handicapping us in the present race for commercial supremacy, because it provides a relatively inferior brain-power which is leading to a relatively reduced national income.

The facts show that in this country we can not depend upon private effort to put matters right. How about local effort?

Anyone who studies the statistics of modern municipalities will see that it is impossible for them to raise rates for the building and upkeep of universities.

The buildings of the most modern university in Germany have cost a million. For upkeep the yearly sums found, chiefly by the State, for German universities of different grades, taking the incomes of seven out of the twenty-two universities as examples, are:

| | | £ |
|---|---|---|
| 1st Class | Berlin | 130,000 |
| 2nd Class | Bonn<br>Göttingen | 56,000 |
| 3rd Class | Königsberg<br>Strassburg | 48,000 |
| 4th Class | Heidelberg<br>Marburg | 37,000 |

Thus if Leeds, which is to have a university, is contene with the 4th class German standard, a rate must be levied of 7*d.* in the pound for yearly expenses, independent of all buildings. But the facts are that our towns are already at the breaking strain. During the last fifty years, in spite of enormous increases in rateable values, the rates have gone up from about 2*s.* to about 7*s.* in the pound for real *local* purposes. But no university can be a merely local institution.

Norman Lockyer.

(*To be concluded.*)

## *MENDEL'S LAW OF HEREDITY.**

What will doubtless rank as one of the great discoveries in biology, and in the

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study of heredity perhaps the greatest, was made by Gregor Mendel, an Austrian monk, in the garden of his cloister, some forty years ago. The discovery was announced in the proceedings of a fairly well-known scientific society, but seems to have attracted little attention and to have been soon forgotten. The Darwinian theory then occupied the center of the scientific stage and Mendel's brilliant discovery was all but unnoticed for a third of a century. Meanwhile the discussion aroused by Weismann's germ-plasm theory, in particular the idea of the non-inheritance of acquired characters, had put the scientific public into a more receptive frame of mind. Mendel's law was rediscovered independently by three different botanists engaged in the study of plant-hybrids—de Vries, Correns and Tschermak—in the year 1900. It remained, however, for a zoologist, Bateson, two years later, to point out the full importance and the wide applicability of the law. Since then the Mendelian discoveries have attracted the attention of biologists generally. Accordingly a brief statement of their underlying principles may not be without interest to others also.

1. *The Law of Dominance.*—When mating occurs between two animals or plants differing in some character, the offspring frequently all exhibit the character of one parent only, in which case that character is said to be '*dominant.*' Thus, when white mice are crossed with gray mice, all the offspring are gray, that color character being dominant. The character which is not seen in the immediate offspring is called '*recessive,*' for though unseen it is still present in the young, as we shall see. White, in the instance given, is the recessive character. The principle of heredity just stated may be called *the law of dominance.* The first instance of it discovered by Mendel related to the cotyledon-color in peas obtained by crossing different garden varieties. Yellow color of cotyledons was found to be dominant over green; likewise, round smooth form of seed was found to be dominant over angular wrinkled form; and violet color of blossoms, over white color. Other illustrations might be mentioned both among animals and among plants, but these will suffice.

2. *Peculiar Hybrid Forms.*—The law of dominance is not of universal applicability; Mendel does not so declare, though some of his critics have thus interpreted him. In many cases the cross-bred offspring possess a character intermediate between those of the parents. This Mendel found to be true when varieties of peas differing in height were crossed.

Again, the cross-breds may possess what appears to be *an intensification of the character of one parent,* as when in crossing dwarf with tall peas the hybrid plant is *taller than either parent,* or as when, in crossing a brown-seeded with a white-seeded variety of bean, the offspring bear beans of a darker brown than those of the brown-seeded parent.

Thirdly, the cross-bred may have a character entirely different from that of either parent. Thus a cross between spotted, black-and-white mice, and albino mice, produces commonly mice entirely gray in color, like the house-mouse. Again, in crossing beans, a variety having yellowish-brown seeds crossed with a white-seeded variety yields sometimes black-mottled seed, a character possessed by neither parent.

These three conditions may be grouped together by saying—the hybrid often possesses *a character of its own,* instead of the pure character of one parent, as is true in cases of complete dominance. The hybrid character may approximate that of one parent or the other, or it may be different from both. There is no way of predicting

what the hybrid character in a given cross will be. It can be determined only by experiment, but it is always the same for the same cross, provided the parents are pure. Often the hybrid form resembles a supposed ancestral condition, in which case it is commonly designated a reversion. Illustrations are the gray hybrid mice, which are indistinguishable in appearance from the house-mouse, and slate-colored pigeons resulting from crossing white with buff pigeons.

3. *Purity of the Germ-cells.*—The great discovery of Mendel is this: *The hybrid, whatever its own character, produces ripe germ-cells which bear only the pure character of one parent or the other.* Thus, when one parent has the character A, and the other the character B, the hybrid will have the character AB, or in cases of simple dominance, A(B)* or B(A). But whatever the character of the hybrid may be, its germ-cells, when mature, will bear *either the character A or the character B, but not both;* and As and Bs will be produced *in equal numbers.* This perfectly simple principle is known as the law of '*segregation,*' or the law of the 'purity of the germ-cells.' It bids fair to prove as fundamental to a right understanding of the facts of heredity as is the law of definite proportions in chemistry. From it follow many important consequences.

A first consequence of the law of purity of the germ-cells is polymorphism of the second and later hybrid generations. The individuals of the first hybrid generation are all of one type, provided the parent individuals were pure. Each has a character resulting from the combination of an A with a B, let us say AB. [In cases of dominance it would more properly be expressed by A (B) or B (A).] But in the next generation three sorts of combinations are possible, since each parent will furnish As and Bs in equal numbers. The possible combinations are AA, AB and BB. The first sort will consist of pure As and will breed true to that character ever afterward, unless crossed with individuals having a different character. Similarly, the third sort will consist of pure Bs and will breed true to that character. But the second sort, AB, will consist of hybrid individuals, like those of which the first hybrid generation was exclusively composed. If, as supposed, germ-cells, A and B, are produced in equal numbers by hybrids of both sexes, and unite at random in fertilization, combinations AA, AB and BB should occur in the frequencies, 1:2:1. For in unions between two sets of gametes, each A+B, there is one chance each for the combinations AA and BB, but two chances for the combination AB.

* The parenthesis is used to indicate a recessive character not *visible* in the individual.

If the three forms AA (or simply A), AB and B are all different in appearance, it will be a very simple matter in an experiment to count those of each class and determine whether they occur in the theoretical proportions, 1:2:1. One such case has been observed by Bateson ( :**02**, p. 183) among Chinese primroses (*Primula sinensis*). An unfixable hybrid variety known as 'giant lavender,' bearing flowers of a lavender color, was produced by crossing

TABLE I.

| Characters, ⟹ | A. | AB. | B. |
|---|---|---|---|
| Plants bearing Flowers in Color | Magenta Red. | Lavender. | White. |
| 1901, Lot 1 | 19 | 27 | 14 |
| 1901, Lot 2 | 9 | 20 | 9 |
| 1902, Lot 1 | 12 | 23 | 11 |
| 1902, Lot 2 | 14 | 26 | 11 |
| Totals | 54 | 96 | 45 |
| Per cent. of whole | 29 | 49+ | 22 |

a magenta red with a white flowering variety tinged faintly with pink. By seed the hybrid constantly produces plants

bearing magenta red and white flowers respectively as well as other plants bearing lavender flowers. The numerical proportions observed in two successive seasons are shown in Table I. The observed numbers, it will be seen, are quite close to the theoretical 1 : 2 : 1.

In cases wherein the hybrid is indistinguishable from one of the parent forms, *i. e.*, in cases of complete dominance of

TABLE II.

HEREDITY OF COTYLEDON-COLOR AMONG CROSS-BRED PEAS.

| Parents Crossed. | Offspring. | | | |
|---|---|---|---|---|
| | Gen. I. | Gen. II. | Gen. III. | Gen. IV. |
| G | Y(G) | 1G......... | G......... | ...G |
| | | | 1G......... | ...G |
| | | 3 { 2Y(G) | 3 { 2Y(G) | |
| | | | 1Y..... | ...Y |
| Y | | 1Y..... | ......Y..... | ...Y |

one parental character, only two categories of offspring will be recognizable and these will be numerically as 3 : 1. But further breeding will allow the separation of the larger group into two subordinate classes—first, individuals bearing only the dominant character; secondly, hybrids; that is, into groups A and A(B), which will be numerically as 1 : 2.

Observed results are in this case also very close to theory. Mendel, by crossing yellow with green peas, obtained, as we have seen, only yellow (hybrid) seed. Plants raised from this seed bore in the same pods both yellow seed and green seed in the ratio 3 : 1. (See Table II.) Under self-fertilization, the green seed produced in later generations green seed only. It bore only the recessive character. Of the yellow seeds, one in three produced only yellow offspring, *i. e.*, contained only the dominant character; but two out of three proved to be hybrid, producing both green and yellow seed, as did the hybrids of the preceding generation. These are precisely the theoretical proportions, A + 2 A(B) + B.

In the case of mice, it has been shown independently by Cuenot (:02) and by the writer's pupil, Mr. G. M. Allen, that the second hybrid generation, obtained by crossing gray with white mice, consists of gray mice and white mice approximately in the ratio 3 : 1. (See Table III.) The white are pure recessives, producing only white offspring, when bred *inter se*. What portion of the grays are pure dominants has not yet been determined with precision, but we may confidently expect that it will prove to be not far from 1 in 3.

TABLE III.

HEREDITY OF COAT-COLOR AMONG CROSS-BRED MICE OBTAINED BY MATING WHITE MICE (W) WITH GRAY MICE (G).

| Parents Crossed. | Offspring. | | |
|---|---|---|---|
| | Gen. I. | Gen. II. | Gen. III. |
| W | G(W) | 1W............. | ...W |
| | | | 1W |
| | | 3 { 2G(W) | 3 { 2G(W) |
| | | | 1G |
| G | | 1G......... | ...G |

A further test of the correctness of Mendel's hypothesis of the purity of the germ-cells and of their production in equal numbers, is afforded by back-crossing of a hybrid with one of the parental forms. For example, take a case of simple dominance, as of cotyledon-color in peas or coat-color in mice. We have here characters D (dominant) and R (recessive). The first generation hybrids will all be D(R). Any one of them back-crossed with the recessive parent will produce fifty per cent. of pure recessive offspring and fifty per cent. of hybrids.

| | |
|---|---|
| For the hybrid produces germ-cells | D + R |
| The recessive parent produces germ-cells ........................ | R + R |
| The possible combinations are.... | 2D(R) + 2R |

This case has been tested for peas and for mice and found to be substantially as stated.

We have thus far considered only cases of cross-breeding between parents differing in a single character. We have seen that in such cases, no new forms, except the unstable hybrid form, are produced. But when the parent forms crossed differ in two or more characters, there will be produced in the second and later hybrid generations individuals possessing *new combinations* of the characters found in the parents; indeed, *all possible combinations* of those characters will be formed, and in the proportions demanded by chance. Thus when parents are crossed which differ in *two* respects, A and B, let us designate the dominant phase of these characters by A, B, the recessive phase by a, b. The immediate offspring resulting from the cross will all be alike, AB(ab),* but the second and later generations of hybrids will contain the stable, *i. e.*, pure classes, AB, Ab, aB, ab, in addition to other (unstable or still hybrid) forms, namely, AB(ab), AB(b), A(a)B, A(a)b and aB(b). In every sixteen second-generation offspring there will be, on the average, one representing each of the stable combinations. Two of the stable combinations will be identical with the parent forms, the other two will be new. The remaining twelve individuals will be hybrid in one or both characters.

An illustration may help to make this case clear. Among domesticated guinea-pigs, as among mice and rabbits, albinism is recessive with respect to pigmented coat. Further, there occur among guinea-pigs individuals known as 'Abyssinians,' whose coat presents a curious rough appearance, for the reason that the hair stands out stiffly from the body in a number of 'cow-licks' or rosettes. In crosses the Abyssinian or rough coat regularly dominates over the normal or smooth coat. Now let us consider what happens when a cross is made involving both these pairs of Mendelian characters, albinism *vs.* pigmented coat, and smooth *vs.* rough coat. If a white Abyssinian is bred to a pigmented smooth guinea-pig, the young are without exception *pigmented* and *rough*, these being the *dominant* members of the two pairs of characters. But the young of course contain in a latent condition the two recessive characters, white coat and smooth coat, which fact may be indicated by designating them as already suggested, AB(ab) [A, a referring to the rough or smooth character of the coat and B, b to its color].

These primary hybrids, if bred *inter se*, will produce young of four different sorts, viz., rough pigmented, rough white, smooth pigmented and smooth white. A certain number of the animals of each sort will *breed true, i. e.*, will produce only their own sort when mated to animals like themselves. Theoretically there should be one *pure* individual of each of the four sorts in a total of sixteen young. The four pure individuals answer to the classes AB, Ab, aB, ab already mentioned.

But, besides these pure individuals, there will occur in three of the four classes *impure* or hybrid individuals, which will transmit to some of their young the dominant character or characters which they themselves possess, but to others of their young the corresponding recessive character or characters. Only the class of smooth white animals (of which there should be one in sixteen young) contains none but pure individuals, for they bear

* This is Mendel's use of lower-case letters to designate recessive characters, with which I have combined the use of a parenthesis when a character by nature recessive is not visible in the individual.

the two recessive characters (ab), and so conceal no hidden recessives. They may at once be set aside as pure. But in the other three classes nothing but actual breeding tests will serve to show which individuals are pure and which impure or hybrid. To each *pure* individual possessing one dominant and one recessive character there will be two others, *exactly like it in appearance*, but hybrid in one pair of characters. This statement applies to the two classes, rough-white and smooth-pigmented, in which the impure individuals would be designated A(a)b and aB(b) respectively. Such impure animals bred *inter se* would produce, in the case of rough-white parents, both rough-white and smooth-white offspring, and in the case of smooth-pigmented parents, both smooth-pigmented and smooth-white offspring.

In the class of rough-pigmented second-generation offspring, which combines the two dominant characters, there will be to each pure individual (AB) eight which are impure in one or both characters. Two of the eight will be hybrid in one character only, as in the rough *vs.* smooth character they form the class A(a)B; two other individuals will be hybrid in the other character, albino *vs.* pigmented, forming the class AB(b); while the remaining four will be hybrid in *both* characters, exactly like the entire first generation of offspring, AB(ab).

The task of the practical breeder who seeks to 'establish' or 'fix' a new variety, produced by cross-breeding, in a case involving two variable characters, is simply the isolation and propagation of that one in each sixteen of the second-generation offspring which will be *pure* as regards the desired combination of characters. Mendel's discovery by putting the breeder in possession of this information enables him to attack his problem systematically, with confidence in the outcome, whereas hitherto his work, important and fascinating as it is, has consisted largely of groping for a treasure in the dark.

The greater the number of separately variable characters involved in a cross, the greater will be the number of new combinations obtainable; the greater, too, will be the number of individuals which it will be necessary to raise in order to secure *all* the possible combinations; and the greater, again, will be the difficulty of isolating the pure, *i. e.*, stable forms from such as are similar to them in appearance but still hybrid in one or more characters. Mendel has generalized these statements substantially as follows: In cases of complete dominance, when the number of differences between the parents is $n$, the number of different classes into which the second generation of offspring fall will be $3^n$, of which $2^n$ will be *pure* (stable); the remainder will be hybrid, though indistinguishable from pure individuals. The smallest number of individuals which in the second hybrid generation will allow of *one pure individual* to each visibly different class will be $4^n$. (See Table IV.)

TABLE IV.

| Number of Differences Between Parents. | Visibly Different Classes, Each Containing One Pure Individual. | Total Classes, Pure and Hybrid. | Smallest Number of Offspring Allowing One Individual to Each Class. | |
|---|---|---|---|---|
| $n$ | $2^n$ | $3^n$ | $4^n$ | |
| 1 | 2 | 3 | 4 | Tested by Mendel for peas and found correct. |
| 2 | 4 | 9 | 16 | |
| 3 | 8 | 27 | 64 | |
| 4 | 16 | 81 | 256 | Calculated. |
| 5 | 32 | 243 | 1024 | |
| 6 | 64 | 729 | 4096 | |

The law of Mendel reduces to an exact science the art of breeding in the case most carefully studied by him, that of entire

dominance. It gives to the breeder a new conception of 'purity.' No animal or plant is 'pure' simply because it is descended from a long line of ancestors possessing a desired combination of characters; but *any* animal or plant is pure if it produces gametes of only one sort, even though its grandparents may among themselves have possessed *opposite* characters. The existence of purity can be established with certainty only by suitable breeding tests (especially by crossing with recessives), but it may be safely assumed for any animal or plant descended from parents which were like each other and had been shown by breeding tests to be pure.

*Special Cases under the Law of Mendel.*—It remains to speak of some special cases under the law of Mendel, which apparently are exceptions to one or another of the principles already stated, and which probably result from exceptional conditions known to us imperfectly. These special cases have come to light in part through Mendel's own work, in part through that of others.

1. *Mosaic Inheritance.*—It occasionally happens that in crosses which bring together a pair of characters commonly related as dominant and recessive, the two characters appear in the offspring in patches side by side, as in piebald animals and parti-colored flowers and fruits. The normal dominance apparently gives place in such cases to a balanced relationship between the alternative characters. What conditions give rise to such relationships is unknown, but when they are once secured they often prove to possess great stability, breeding true *inter se*. This, for example, is the case in spotted mice, which usually produce a large majority of spotted offspring. The balanced relationship of characters possessed by the parents is transmitted to the germ-cells, which are, not as in ordinary hybrid individuals D or R, but DR. This has been shown to be the case in spotted mice by Mr. Allen and myself, in a paper published elsewhere. (Castle and Allen, :03.)

2. *Stable Hybrid Forms.*—This is a case, in some respects similar to the last, which was familiar to Mendel (:70) himself. It sometimes happens, as we have seen, that the hybrid has a form of its own different from that of either parent. To such cases the law of dominance evidently does not apply. In a few cases—*Hieracium* hybrids (Mendel), *Salix* hybrids (Wichura) —it has been found that the hybrid form does not break up in the second generation and produce individuals like the grandparents, but breeds true to its own hybrid character. This can be explained only on one of two assumptions. Either the germ-cells bear the two characters in the balanced relationship, AB, as do those of spotted mice, or, of the two gametes which unite in fertilization, one invariably bears the character A, the other the character B. Of the two explanations, the former seems at present much the more probable.

3. *Coupled Characters.*—This is the phenomenon of correlation of characters in heredity. It is sometimes found that, in cross-breeding, two characters can not be separated. When one is inherited, the other is inherited also. Thus, in crossing different sorts of *Datura* (the Jamestown weed) it has been found that purple color of stem invariably goes with blue color of flowers, whereas green stems are constantly associated with white flowers. Again in mice, rabbits and most other mammals, white hair and pink eyes commonly occur together and may not be separated in heredity. Very rarely, however, as I have observed, an otherwise perfectly white guinea-pig has dark eyes; further the ordinary albino guinea-pig

with pink eyes has usually smutty (brown-pigmented) ears, nose and feet; and a race of mice with pink eyes, though partially pigmented coat, has formed the basis of some recent important experiments in heredity conducted by Darbishire (:02, :03) at Oxford, England. These exceptional conditions probably represent stable couplings of a *part only* of the dominant character (pigmented coat) with the recessive character (white coat), and are similar in kind to the DR character of spotted mice.

Further, coupling may occur between a number of characters greater than two, so that they form, to all intents and purposes, in heredity, one indissoluble compound character. Thus, Correns (:00) observed that in crosses between two species of stocks (*Mathiola incana* DC. and *M. glabra* DC.) the second generation hybrids showed reversion to one or the other of the parental forms in *all three of the principal differential characters* studied, viz., hairy or glabrous stems, violet or yellow-white flowers, and blue or yellow seed. A blue seed always produced a hoary plant bearing violet flowers; a yellow seed always produced a glabrous plant bearing yellow or white flowers.

4. *Disintegration of Characters.*—This is the converse of the foregoing process. Not only may characters apparently simple be coupled together in heredity to form composite units of a higher order, but characters which ordinarily behave as units may as a result of crossing undergo disintegration into elements separately transmissible. Thus the gray coat-color of the house-mouse is always transmitted as a dominant unit in primary crosses with its white variety; but in the second cross-bred generation a certain number of *black* mice appear, some or all of which are probably hybrids. For similar black mice obtained by crossing black-white with white mice have been shown, by breeding tests, to be hybrids, since on crossing with white mice they produce white mice, black mice, and, in one or two cases, gray mice also. Accordingly black mice clearly belong with grays in the category of dominant individuals [D or D (R)], but they have visibly *only the black constituent* of the gray coat, the remaining constituent, a rufous tint, having been separated from the black in consequence of cross-breeding. There is reason to believe that the rufous constituent may become recessive, *i. e.*, latent, either in the black individuals or in the reverted whites, or in both. It is seen separated from both the black and the white characters, in the chocolate-brown and reddish-yellow individuals obtained in cross-breeding.

A fancier of rabbits tells me that there occurs a similar disintegration of the composite coat-color of the 'Belgian hare,' when that animal is crossed with ordinary white rabbits, the result being the production of black, yellow and mottled individuals, in addition to ordinary gray-browns.

The various distinct colors or color patches of the guinea-pig have doubtless originated in a similar way—by resolution of the composite coat-color of the wild *Cavia*, upon crossing with an albino sport. This subject is now undergoing investigation.

Correns (:00) mentions a case in plants, which probably belongs in this same category. In crossing the blue-flowered (dominant) *Mathiola incana* with the yellowish-white-flowered (recessive) *M. glabra*, the second generation recessives produced in some cases pure white flowers, in others yellow flowers. In this case the recessive character, rather than the dominant, underwent disintegration.

5. *Departures from the Theoretical*

*Ratios of Dominants to Recessives.*—Considerable departures are to be expected when the number of offspring taken into consideration is small, but with increase in the number of offspring examined, the departures should grow less. This is usually found to be true. Mendel's numbers are shown by Weldon (:02) to be well within the limits of probable error. But certain cases have been observed in which departures of a particular sort persist even with considerable numbers of offspring. Thus Allen and I have found the recessive character, white, in mice to be inherited in about three per cent. more than the calculated number of cases, while the equally recessive dancing character is inherited in about thirty-three per cent. less than the calculated number of cases. These fairly uniform departures indicate, to my mind, a vitality, on the part of the recessive gamete, in one case somewhat superior, in the other much inferior, to that of the dominant gamete. Inferior vitality of gametes of either sort would result in greater mortality and so in a diminished number of individuals derived from such gametes.

Of course other explanations are possible, as, that the two sorts of gametes are *not* produced in equal numbers. More extended investigations of such cases can alone make their meaning clear.

6. *Reversal of Dominance.*—Exceptional cases are on record in which crossing of a dominant with a recessive has resulted in the production of *pure* dominants, or recessives, instead of hybrids. Such cases are, I believe, correctly referred by Bateson to the category of 'false hybridization' as described by Millardet, a phenomenon akin to parthenogenesis, in which sexual union has served merely to *stimulate one gamete to development* without bringing about its union with the other gamete.

It is possible, however, that there are cases in which one of a pair of characters is sometimes dominant, sometimes recessive. Tschermak (:01) believes that he has found a few such cases among crossbred beans. Sex and certain other dimorphic conditions found in the higher animals and plants may prove to be cases of this sort.

Acceptance of Mendel's principles of heredity as correct must lead one to regard discontinuous (or sport) variation as of the highest importance in bringing about polymorphism of species and ultimately of the formation of new species.

A sport having once arisen affecting some one character of a species, may by crossing with the parent form be the cause of no end of disintegration on the part of any or all of the characters of the species, and the disintegrated characters may, indeed *must*, form a great variety of new combinations of characters, some of which will prove stable and self-perpetuating. Even if a particular combination of characters is uniformly eliminated by natural selection under one set of conditions, it may reappear again and again, and finally meet with conditions which insure its success.

We now have an explanation of the long-recognized principle that new types of organisms are extremely variable, whereas old types vary little. A new type which has arisen as a sport will cross with the parent form. The offspring will then inherit some characters dominant, others latent, and polymorphism of the race results. Only selection continued through long periods of time will serve to eliminate completely the latent recessives, and so to cause the disappearance of certain aberrant variations.

Bateson makes the pregnant suggestion that even cases of continuous variation may possibly prove conformable with Men-

delian principles. Take, for example, the height of peas. It has been found in certain crosses of a tall with a dwarf variety of pea, that the hybrid has an intermediate height. Now, if the hybrid produces pure germ-cells, dwarf and tall respectively, in equal numbers, the next generation will consist of three classes of individuals, dwarf, intermediate and tall, in the proportions 1:2:1. But if each of the original characters should undergo disintegration, we might get a dozen classes, instead of three, resulting in a practically continuous frequency-of-error curve.

SUMMARY.

1. The basic principle in Mendel's discoveries is that of the purity of the germ-cells; in accordance with this a cross-bred animal or plant produces germ-cells bearing *only one* of each pair of characters in which its parents differ. From it follows the occurrence in the second and later hybrid generations of a definite number of forms in definite numerical proportions.

2. Mendel's principle of dominance is realized in the heredity of a considerable number of characters among both animals and plants. In accordance with this principle, hybrid offspring have visibly the character of only one parent or the other, though they transmit those of both parents.

3. In other cases the hybrid has a distinctive character of its own. This may approximate more or less closely the character of one parent or the other, or it may be entirely different from both. Frequently the distinctive hybrid character resembles a lost ancestral character. In some cases of this sort, as in coat-color of mammals, the hybrid character probably results from a recombination of the characters seen in one or both parents, with certain other characters latent (that is, recessive) in one parent or the other.

4. There have been observed the following exceptions to the principle of dominance, or to the principle of purity of the germ-cells, or to both:

(*a*) Mosaic inheritance, in which a pair of characters ordinarily related as dominant and recessive occur in a balanced relationship, side by side in the hybrid individual and frequently in its germ-cells also. This balanced condition, once obtained, is usually stable under close breeding, but is readily disturbed by cross-breeding, giving place then to the normal dominance.

(*b*) Stable (self-perpetuating) hybrid forms result from certain crosses. These constitute an exception to both the law of dominance and to that of purity of the germ-cells. For the hybrid is like neither parent, but the characters of *both* parents exist in a stable union in the mature germ-cells produced by the hybrid.

(*c*) Coupling, *i. e.*, complete correlation may exist between two or more characters, so that they form a compound unit not separable in heredity, at least in certain crosses.

(*d*) Disintegration of characters apparently simple may take place in consequence of cross-breeding.

(*e*) Departures from the expected ratios of dominants to recessives may be explained in some cases as due to inferior vigor, and so greater mortality, on the part of dominants or recessives respectively.

(*f*) Cases of apparent reversal of dominance may arise from 'false hybridization' (induced parthenogenesis). Possibly in other cases the determination of dominance rests with circumstances as yet unknown.

5. Mendel's principles strengthen the view that species arise by discontinuous variation. They explain why new types are especially variable, how one variation

causes others, and why certain variations are so persistent in their occurrence.

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:00. 'G. Mendel's Regeln über das Verhalten der Nachkommenschaft der Rassenbastarde.' *Ber. deutsch. bot. Gesellsch.*, Jahrg. 18, pp. 158–168.

Cuénot, L.
:02. 'La loi de Mendel et l'hérédité, de la pigmentation chez les souris.' *Compt. Rend.*, Paris, Tom. 134, pp. 779–781.

Darbishire, A. D.
:02. 'Notes on the Results of Crossing Japanese Waltzing Mice with European Albino Races.' *Biometrika*, Vol. 2, Pt. 1, pp. 101–104, 4 figs.

Darbishire, A. D.
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:66. 'Versuche über Pflanzenhybriden. *Verh. Naturf.-Vereins in Brünn*, Bd. 4, Abh., pp. 3–47. (Translation in Bateson, :02.)

Mendel, G.
:70. 'Ueber einige aus künstlicher Befruchtung entnomennen *Hieracium-Bastarde.*' *Verh. Naturf.-Vereins in Brünn*, Bd. 8, Abh., pp. 26–31. (Translation in Bateson, :02.)

Tschermak, E.
:00. 'Ueber künstliche Kreuzung bei *Pisum sativum.*' *Zeitsch. f. landwirths. Versuchswesen in Oester.*, Jahrg. 3, pp. 465–555.

Tschermak, E.
:01. 'Weitere Beiträge über Verschiedenwerthigkeit der Merkmale bei Kreuzung von Erbsen und Bohnen.' (Vorläufige Mittheilung.) *Ber. deutsch. bot. Gesellsch.*, Jahrg. 19; pp. 35–51.

Vries, H. de.
:00. 'Sur la loi de disjonction des hybrides.' *Compt. Rend.*, Paris, Tom. 130, pp. 845–847.

Vries, H. de.
:00. 'Das Spaltungsgesetz der Bastarden.' *Ber. deutsch. bot. Gesellsch.*, Jahrg. 18, pp. 83–90.

Weldon, W. F. R.
:02. 'Mendel's Laws of Alternative Inheritance in Peas.' *Biometrika*, Vol. 1, pp. 228–254, pl. 1, 2.

W. E. Castle.
Harvard University.

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## *WILBUR CLINTON KNIGHT.*

The subject of this sketch was born on a farm at Rochelle, Illinois, December 13, 1858. Early in his boyhood his parents, Mr. and Mrs. David A. Knight, removed to a farm at no great distance from Lincoln, Nebraska. Here he grew to young manhood, gaining the strength of body and mind which is so often developed in unfettered country life. Self-reliance and strength of character came to him in the struggle that he, in common with the other members of the family, had put forth in what was then the new west, in order to wrest from nature the daily bread. Life in all of its forms, and the hills and rocks appealed strongly to him. By the time that he had secured such education as the country school afforded he had also become more than ordinarily familiar with the fauna, the flora and the geological formations of his neighborhood.

Being unusually fond of athletic sports, of fishing and of hunting, he led many a merry party in these pursuits, frequently to the complete exhaustion of most of his fellows. In more recent years, his many friends who at one time or another shared

camp life with him in the Rocky Mountains remember not only his skill with rod and gun but more particularly their dismay as they tried to follow those long swinging strides that carried him over mountain and plain. The restless energy of the naturalist-explorer was his, and day after day he urged himself from locality to locality in search of new finds. Even when loaded down (as he usually was) with collecting implements, specimen bag and camera he seemed never to tire.

As early as his means would allow, he entered the University of Nebraska, from which he graduated in 1886, receiving the degree B.Sc. As a student there he early demonstrated his scientific tendencies. The biological sciences and especially geology were his delight. Under the inspiration which Dr. Bessey always exercises upon his students, Mr. Knight seriously contemplated taking up botany as his life work, and while his inclination to study the rocks and the story that they reveal proved stronger, he never lost his interest in the flora of the great plains and the mountains where his life was spent.

He was at various times a graduate student at the University of Nebraska, his alma mater, from which he received the degree of M.A. in 1893 and the doctorate in philosophy, in 1901. He had also studied for a short time at the University of Chicago.

After all has been said about his work in the schools, those who knew him best understand that his degrees represent not what he carried *away* from the class-room and laboratory, but rather what he carried *to* these as he came fresh from the fields that he had explored. When he presented himself before academic faculties for examination the funds of knowledge that interested those faculties were not facts that he had gleaned from books but those that he had at first hand. He read widely and assimilated much, but he accepted little on mere 'authority.' True scientist that he was, he accepted statements cautiously, unless the facts upon which they were founded were apparent. If his own experience confirmed or if he were able to verify, he accepted all truth with joy. In the field he was a keen observer and he soon accumulated a store of facts upon which he based his hypotheses and later his more mature judgments. When he had reached a conclusion, he modestly yet firmly held to that conclusion unless it could be shown that he was in error about the underlying facts.

He had a wide acquaintance among scientific men, many of whom he had personally met. The great expedition to the fossil fields of Wyoming, in 1899, which he so successfully conducted, brought him into contact with scores of men who recall those weeks as a time of profit and delight and Professor Knight as a cherished personal friend.

Dr. Knight was great not merely from a scholastic point of view, but quite as much from the grasp he had upon economic questions. He was actively in touch with the industrial problems of his state, and his opinions were eagerly sought by corporate as well as private interests. This drew him into many and diverse fields, as the appended partial list of his publications will show.

To the University of Wyoming he had made himself indispensable. Elected to the chair of geology and mining engineering in 1893, he continued in that position, with the added duties of principal of the school of mines, until his death. Faculty and students alike recognized in him a successful teacher, a wise counselor and a true friend.

The other positions that he held at various times may only be mentioned: Assistant territorial geologist, 1886–7; as-

sayer at Cheyenne, 1887–8; superintendent of mines, Colorado and Wyoming, 1888–93; state geologist, 1898–9; for many years consulting expert to the Union Pacific Railroad Company upon mineral and oil lands and upon artesian basins; at the time of his death, on leave from the university, consulting expert for the Belgo-American Oil Company.

Among the honors that had come to him, membership in the following learned societies should be noted: Fellow of the Geological Society of America, member of the American Institute of Mining Engineers, member of the National Geographical Society.

Of his home relations it may be said that they illustrated the best in American domestic and social life. His parents survive him and are justly proud of the work that he had accomplished—for in his brief forty-four years he had more to his credit than most of the scientific men who are permitted to round out their three score years and ten.

He was married in 1889 to E. Emma Howell, a delightful and talented young woman whom he had known during his college career. The union proved a most happy one and the four promising children (one daughter and three sons) are the joy of the loving wife that mourns the loss of a tender and devoted husband.

The home of Mr. and Mrs. Knight was always open to their friends, and they took great pleasure in providing social occasions that should serve other purposes than merely that of killing time.

In the passing away of Professor Knight, on July 28, 1903, after a few days' illness from peritonitis, the family lost its hero, the community a choice citizen, the university an honored member, the state an important agent in its industrial development, the scientific world one who, having done much, was just on the threshold of greater things, and the church a member who lived the religion that he professed.

Aven Nelson.

University of Wyoming,
Laramie, Wyo.

A LIST OF PAPERS PUBLISHED BY WILBUR C. KNIGHT.

Bulletin No. 14, Wyoming Experiment Station, University of Wyoming; 'Geology of the Wyoming Experiment Farms, and Notes on the Mineral Resources of the State,' October, 1893.

'The Coal Mines of Wyoming,' *Mineral Industry*, 1894.

'Coal and Coal Measures of Wyoming,' 16th Annual Report, U. S. G. S., Part IV., 1894.

'A New Jurassic Plesiosaur from Wyoming,' Science, October 4, 1895.

'The Mining Industry of Wyoming,' *Mining Industry* (Denver), June, 1896.

Bulletin No. I., Petroleum Series, School of Mines University of Wyoming; 'The Petroleum of the Salt Creek Oil Field, its Technology and Geology,' June, 1896.

'The Salt Creek Oil Field,' *Engineering and Mining Journal*, January, 1896.

'The Petroleum Fields of Wyoming,' *Mineral Industry*, 1896.

'The Petroleum Industry of Wyoming,' *American Manufacturer and Iron World*, May 29, 1896.

Bulletin No. II., Petroleum Series, School of Mines, University of Wyoming; 'The Petroleum Oil Fields of the Shoshone Anticlinal, Geology of the Popo Agie, Lander and Shoshone Oil Fields,' January, 1897.

'The Wyoming Natural Soda Deposits,' *Mineral Industry*, 1897.

'The Origin of the Soda Deposits of Wyoming,' *Mining Industry* (Denver), November, 1898.

'Prehistoric Quartzite Quarries of Eastern Central Wyoming,' Science, March 4, 1898.

'Some New Jurassic Vertebrates from Wyoming,' *American Journal of Science*, Vol. V., 1898. First and second papers.

'Description of Bentonite, a new variety of Clay,' *Engineering and Mining Journal*, LXIII. and LXVI.

Bulletin No. III., Petroleum Series, School of Mines, University of Wyoming; 'The Geology of the Oil Fields of Crook and Uinta Counties,' November, 1899.

'Some New Data for Converting Geological Time into Years,' Science, October 4, 1899.

'The Permian of Nebraska,' *Journal of Geology*, May–June, 1899.

'Jurassic Rocks of Southeastern Wyoming,' Bulletin of the Geological Society of America, Vol. XI., 1900.

'The Present Outlook of the Coal Industry in Wyoming,' *Wyoming Industrial Journal*, June, 1900.

'Some New Jurassic Vertebrates from Wyoming,' Third Paper, *American Journal of Science*, August, 1900.

Bulletin No. 45, Wyoming Experiment Station, University of Wyoming; 'A Preliminary Report of the Artesian Basins of Wyoming, June, 1900.'

'The Fossil Field Expedition of 1899,' *National Geographical Magazine*, December, 1900.

'Potassium Nitrate in Wyoming,' SCIENCE, January 25, 1901.

'Geology of Bates's Hole,' *Bulletin Geological Society of America*, Vol. XII., 1901.

Special Bulletin, School of Mines, University of Wyoming; 'The Swetwater Mining District.'

Bulletin No. IV., Petroleum Series, School of Mines, University of Wyoming, 'Geology of the Oil Fields of the Natrona Country, excepting Salt Creek.'

'The Laramie Plains Red Beds and Their Age,' *Journal of Geology*, Vol. X., No. 4, 1902.

Bulletin No. 49, Wyoming Experiment Station, University of Wyoming; 'Alkali Lakes and Deposits (Alkali Series IV.).' Experiment Station.

'The Coal Fields of Southern Uinta County,' *Bulletin of the Geological Society of America*, Vol. XIII.

'The Petroleum Industry of Wyoming,' 22d Annual Report of the Director of the Geological Survey.

'Wyoming Copper Development,' *Mineral Industry*, 1901.

'Wyoming Gold Outlook,' *Mineral Industry*, 1902.

Bulletin No. V., Petroleum Series, School of Mines, University of Wyoming; 'The Newcastle Oil Field.'

'Discovery of Platinum in Wyoming,' *Engineering and Mining Journal*, LXII., 845.

'Petroleum Fields of Wyoming,' *Engineering and Mining Journal*, LXII., 358 and 628.

'Wyoming Oil,' *Petroleum Review*, London.

'Rare Metals in the Ore from The Rambler Mine, Wyoming,' *Engineering and Mining Journal*, LXIII., No. 2.

'Epsom Salts Deposits of Wyoming,' *Engineering and Mining Journal*, February 14, 1903.

'Petroleum Fields of Wyoming,' *Engineering and Mining Journal*, May 24, 1902.

'Mining in Wyoming in 1902,' *Engineering and Mining Journal*, January 3, 1903.

Bulletin No. 55, Wyoming Experiment Station, University of Wyoming; 'The Birds of Wyoming.'

'The Geology of the Leucite Hills of Wyoming.' (In collaboration with Dr. J. F. Kemp.) *Bulletin of the Geological Society of America*, 1903.

'Fossil Elephants in Wyoming,' SCIENCE, 1903.

'Notes on *Baptanadon marshi*, n. s.,' *American Journal of Science*, July, 1903.

Bulletin No. VI., Petroleum Series, School of Mines, University of Wyoming; 'The Bonanza, Cottonwood and Douglas Oil Fields,' July, 1903.

## *SCIENTIFIC BOOKS.*

*Lehrbuch der vergleichenden Histologie der Tiere.* Von Dr. KARL CAMILLO SCHNEIDER, Privatdozent an der Univ. Wien, mit 691 Abbildungen im Text. Jena, Verlag von Gustav Fischer. 1902.

This comparative histology is another instance of the astonishingly brief time in which, in Vienna, a great work may be brought to completion. The heavy volume of 939 pages contains also a bibliography of 36 pages and an index.

The work is divided into a general and a special part. The plan has been to bring together in the general part the weightiest results for comparison by a presentation of the leading points of view, while in the special part leading groups are treated by taking up typical representatives in detail.

This plan has not been carried out completely, however. A number of groups, especially the Tunicata, and still further the Trematoda, Acanthocephala, Rotatoria, Siphunculoidea, Cephalopoda, Myriapoda, Arachnoidea, Scyphomedusa, Ophiuroidea, Echinoidea, Bryozoa, Brachiopoda, typical fishes, reptiles and birds, have not been considered at all or only superficially. Even the remaining types have not been worked up with the completeness one might wish. Still the work is a remarkable and valuable one. The text, to a considerable extent, is based on the researches of the author, while the literature, to which extensive reference is made, has served chiefly as control. Wherever the author has been dependent on literature

alone for his view, credit is given and the literature cited.

In the general part, the incompleteness of the chapter on 'Organology' is noticeable. While in many respects the material has not been sufficiently worked up, in other respects it has been carried beyond the borders of comparative histology. In the general part, the chapter on 'Architectonics,' the different planes of organization of the Metazoa have been discussed, and at the close of the chapter a system (page 238) has been devised which is the key to the systematic arrangement of the special part.

Histology, in this book, is not considered entirely in the sense of microscopic anatomy, but primarily as morphological cytology. Tissues are associations of cells of the same sort. In discussing tissues the author concerns himself first with their structural characteristics, but secondly, also with their relation to the composition of the entire organism.

The dividing of the Metazoa into two principal groups, the Pleromata and the Cœlenterata, is based, for a great part, on histologic grounds.

It is very evident the author has worked with a plan or outline in hand which has enabled him to produce a well-written, usable book. Of the 691 illustrations many are excellent, while only a few give one the feeling that the work was done under pressure. As a work of reference the book is very valuable, for it embodies not only much that is original, but the results of hundreds of investigators have been worked over and embodied in the text. As a text-book it is, of course, entirely too bulky to be considered. Still when one considers the remarkable activity in Germany in the field of microscopic anatomy as illustrated in Oppel's 'Vergleichende Mikroskopische Anatomie der Wirbeltiere,' three large volumes with a total of 2,400 pages in which the author has but completed his consideration of the alimentary tract, one is led to feel that in another decade Schneider's work may be a primer.

BURTON D. MYERS.

INDIANA UNIVERSITY,
BLOOMINGTON, INDIANA.

## *SOCIETIES AND ACADEMIES.*

### AMERICAN MATHEMATICAL SOCIETY.

THE tenth summer meeting and fourth colloquium of the American Mathematical Society were held at the Massachusetts Institute of Technology during the week August 31 to September 6, 1903. Forty-seven members of the society attended the sessions of the regular meeting, which occupied the first two days of the week. The colloquium opened on Wednesday morning, with a total attendance of thirty-one. Three courses of lectures were given, as follows: Professor E. B. Van Vleck, of Wesleyan University, six lectures on 'Selected Topics in the Theory of Divergent Series and of Continued Fractions'; Professor H. S. White, of Northwestern University, three lectures on 'Linear Systems of Curves on Algebraic Surfaces'; Professor F. S. Woods, of the Massachusetts Institute of Technology, three lectures on 'The Connectivity of Non-Euclidean Space.'

The following persons were elected to membership in the society: Professor D. P. Bartlett, Massachusetts Institute of Technology; Professor C. E. Comstock, Bradley Polytechnic Institute, Peoria, Ill.; Mr. H. N. Davis, Harvard University; Mr. W. J. Graham, New York, N. Y.; Mr. N. J. Lennes, Chicago, Ill.; Mr. T. J. McCormack, La Salle, Ill.; Dr. L. I. Neikirk, University of Pennsylvania; Dr. A. B. Pierce, University of Michigan; Professor W. J. Rush, Iowa College; Miss M. E. Trueblood, Mt. Holyoke College; Mr. C. B. Upton, Columbia University; Dr. Oswald Veblen, University of Chicago; Mr. R. H. Williams, Columbia University. Seventeen applications for membership were received.

The committee on definitions of college entrance requirements in mathematics, appointed at the summer meeting of 1902, presented a report, which was received and recommended for publication. The report will appear in the *Educational Review* and in the *Bulletin* of the society. A committee was appointed to prepare for the October meeting a list of nominations of officers and members of the Council for the year 1904.

The following papers were read at this meeting.

I. J. SCHWATT: 'On the length of curves.'

T. J. I'A. BROMWICH: 'Similar conics through three points.'

D. R. CURTISS: 'Binary families in a triply connected region, with especial reference to hypergeometric families.'

JOHN EIESLAND: 'On a certain system of conjugate lines on a surface transformable into asymptotic lines by means of Euler's transformation.'

EDWARD KASNER: 'A class of conformal transformations.'

EDWARD KASNER: 'Notes in the theory of surfaces.'

E. R. HEDRICK: 'Note on the existence of a continuous first derivative.'

G. A. BLISS: 'Jacobi's condition in the calculus of variations when both end points are variable.'

ARNOLD EMCH: 'Note on the $p$-discriminant of ordinary differential equations of the first order.'

HELEN A. MERRILL: 'On a notable class of linear differential equations of the second order.'

FLORIAN CAJORI: 'On the circle of convergence of the powers of a power series' (preliminary communication).

E. T. WHITTAKER: 'An expression of certain known functions as generalized hypergeometric functions.'

W. H. YOUNG: 'On a test for non-uniform convergence.'

J. I. HUTCHINSON: 'On the automorphic functions of signature (0, 3; 2, 6, 6).'

B. O. PEIRCE: 'On the lines of certain classes of solenoidal or lamellar vectors symmetric with respect to an axis.'

H. T. EDDY: 'The multiplication of complex numbers and of vectors compared.'

J. N. VAN DER VRIES: 'On monoids.'

JACOB WESTLUND: 'On the congruence $x^{\phi(P)} \equiv 1$ mod. $P^n$.'

ALFRED LOEWY: 'Zur Gruppentheorie mit Anwendungen auf die Theorie der linearen homogenen Differentialgleichungen.'

SAUL EPSTEEN: 'Semireducible hypercomplex number systems.'

L. E. DICKSON: 'On the subgroups of order a power of $p$ in the quaternary abelian group in the Galois field of order $p^n$.'

L. E. DICKSON: 'The subgroups of order a power of 2 of the simple quinary orthogonal group in the Galois field of order $p_n = 8l \pm 3$.'

L. E. DICKSON: 'Determination of all groups of binary linear substitutions with integral coefficients taken modulo 3 and of determinant unity.'

L. E. DICKSON: 'Determination of all the subgroups of the known simple group of order 25920.'

L. E. DICKSON: 'The systems of subgroups of the quaternary abelian group in a general Galois field.'

C. N. HASKINS: 'On the invariants of quadratic differential forms.'

FRANK MORLEY: 'On projective coordinates.'

FRANK MORLEY: 'On a skew quadrangle covariant with six points of space' (preliminary communication).

E. B. WILSON: 'The projective definition of area.'

R. S. WOODWARD: 'On the values of the stretches and the slides in the theory of strain.'

R. S. WOODWARD: 'The radial compressibility of the earth compatible with the Laplacian law of density distribution.'

E. O. LOVETT: 'Periodic solutions of the problem of four bodies.'

E. O. LOVETT: 'Central conservative systems with prescribed trajectories.'

S. E. SLOCUM: 'Rational formulas for the strength of concrete-steel beams.'

A. S. CHESSIN: 'On a class of linear differential equations.'

C. M. MASON: 'On certain systems of differential equations: generalization of Green's functions, analytic character of the solutions.'

E. V. HUNTINGTON: 'A set of independent postulates for the algebra of logic.'

Pleasant social features of the meeting were the reception tendered to the society by Professor and Mrs. Pickering, at the Harvard College Observatory, where the rich collection of stellar photographs was visited under Professor Pickering's guidance; several informal and well-attended dinners and evening gatherings; and on Thursday afternoon an excursion to Nantasket in Boston harbor.

The next meeting of the society will be held at Columbia University, on Saturday, October 31.

F. N. COLE,
*Secretary.*

## DISCUSSION AND CORRESPONDENCE.

### TOXIC EFFECT OF ACIDS ON SEEDLINGS.

IN a recent number of SCIENCE (Vol. XVIII., p. 453, September 4, 1903) there is a communication describing the effect of solutions of certain bases and acids upon seedlings

of Indian corn. This paper is remarkable in that no mention is made of the previous work of Heald* upon this plant, although the work of Kahlenberg and True, suggesting Heald's work, and published at the same time, in the same journal,† is freely quoted. This omission is the more remarkable since the author's results, when working with acids, are widely different from those obtained by Heald. The undersigned, in collaboration with Mr. J. F. Breazeale, had occasion last winter to repeat the work of Heald, working to closer limits than that investigator had found desirable. It may be worth while to state the results of these three investigations as to the limit of dilution for various acids with seedlings of corn.

| | Loew. | Heald. | Cameron and Breazeale. |
|---|---|---|---|
| Hydrochloric acid.. | n/512 | n/3,200 | n/3,000. |
| Sulphuric acid..... | n/512 | n/3,200 | n/3,000. |
| Nitric acid........ | | n/3,200 | n/2,250. |
| Hydrobromic acid.. | | n/3,200 | |
| Acetic acid......... | | n/400 ‡ | n/850. |
| Malic acid......... | | | n/1,250. |
| Oxalic acid........ | | | n/1,750. |
| Succinic acid....... | | | n/600. |

Just what is meant by 'toxic limit' seems to be somewhat indefinite judging from the printed descriptions of the work of this kind, but in the three investigations under consideration the same methods of work and the same, or very similar, criteria have been used, and the comparison seems to be fair. The confirmation of the results of Heald by those obtained in my own laboratory makes those of Loew the more inexplicable.

The author expresses astonishment that the limits for maize should vary so widely from that found for *Lupinus albus* by Kahlenberg and True. The work in my own laboratory, as well as that of Heald, has shown that very much greater differences exist when other plants are involved, and that *a priori* predications upon this point are at present impossible.

* *Bot. Gazette*, 22, 125 (1896).

† *Bot. Gazette*, 22, 81 (1896).

‡ So stated in Heald's tabulation, but from the description of his experiments it seems probable that this is a typographical slip, and should be n/800.

He also seems to have difficulty in understanding the relative action of kations in the presence of more toxic anions. The literature of this subject is now fairly large, as witness the work of Loeb in Chicago, Coupin in France, not to mention a number of other investigators, and this particular point has been specifically discussed in connection with agricultural plants by Kearney and myself,* and more recently by True and Gies,† although no reference is made to any of these investigations in the paper under discussion. It may be well to state here that the work done in my laboratory, which I have already communicated to the American Chemical Society at its meeting in Cleveland, Ohio, June 30, 1903, will be described shortly from a technical point of view in the *Journal of Physical Chemistry,* and its value for and bearing upon certain important agricultural questions will be fully discussed in an early publication from the Department of Agriculture.

F. K. CAMERON.

U. S. DEPT. OF AGRICULTURE, BUREAU OF SOILS, WASHINGTON, D. C., September 7, 1903.

* Report 71, U. S. Dept. of Agriculture (1902)

† *Torrey Botanical Club*, 30, 390 (1903).

## SHORTER ARTICLES.

### PRIMITIVE FLAGEOLETS.

THERE is a kind of primitive flageolet made by the western tribes of North American Indians as follows: A section of cane is open at both ends, but has a joint between the ends; the septum of this joint closes the tube. Two holes from three sixteenths to one fourth of an inch in diameter are made from the outside into the cavity, close to and on opposite sides of the septum. A shallow air channel is cut in the outside of the cane from one hole to the other, and three, four or six finger holes are made in the cane in the part below the septum. The Rees and Shoshones make a septum of wax. When so constructed and nothing further added the 'mystery flute,' described by early writers, is completed when the upper of the two holes at the septum and the air channel are covered by a finger. Blowing through the cane from the upper end produces a sound whose pitch is changed by the finger holes.

The mystery consists in placing the finger over the upper hole and air channel exactly in the correct place. Usually a piece of cloth, skin, etc., is tied around the cane at this point.

The National Museum has specimens of this instrument from the following tribes, viz., Apaches, Cocopas, Mohaves, Papagos, Pimas, Rees and Shoshones. Other examples have a tube with septum made by splitting a cylinder, excavating the halves and gluing them together.

I had supposed until recently that this method of constructing the flageolet was not to be found outside of North America. I have never read a description of this instrument except from travelers in North America. But recently in a collection of specimens made by Dr. W. L. Abbott, at Siaba Bay, Island of Nias, off the west coast of Sumatra, I find a specimen made in the manner stated above except that in the place of a septum the bore of the cane is plugged with wax. The covering of the upper hole and air channel is a long leaf wrapped around and protected by a bandage of cotton sheeting.

It has seven finger holes and a thumb hole. Its Malay name is Siro'oni.

E. H. HAWLEY.

## SCIENTIFIC AND TECHNICAL EXAMINATIONS.

THE United States Civil Service Commission invites special attention to the examinations which will be held, beginning October 21, 1903, at various places throughout the United States, for the following-named positions:

Acting assistant-surgeon, Public Health and Marine Hospital Service.
Aid, Coast and Geodetic Survey.
Assistant examiner, Patent Office.
Assistant (scientific), Department of Agriculture.
Bookkeeper, Departmental Service.
Civil and electrical engineer, Departmental Service.
Civil and electrical engineer, Philippine Service.
Civil engineer and draftsman.
Computer:
  Coast and Geodetic Survey.
  Nautical Almanac Office.
  Naval Observatory.
Deck officer, Coast and Geodetic Survey.
Draftsman:
  Architectural.
  Copyist, topographic.
  Junior architectural.
  Topographic, Land Office Service.
Electrical engineer and draftsman.
Engineering and hydrographic aid.
Farmer—industrial teacher.
Farmer—industrial teacher with a knowledge of irrigation.
Fish culturist.
Irrigation engineer.
Kindergarten teacher.
Manual training teacher.
Matron — seamstress — female industrial teacher.
Meat inspector.
Mechanical and electrical engineer.
Observer.
Pharmacist, Public Health and Marine-Hospital Service.
Physician, Indian Service.
Superintendent of construction.
Teacher, Indian Service.
Trained nurse, Indian Service.
Trained nurse, Philippine Service.

As the demand for persons with these qualifications is greater than the present supply, the Commission invites all persons who are qualified to take these examinations, as they offer an excellent opportunity to enter the Federal service, with good prospect for advancement. Information concerning the character of these examinations, the required qualification, age limits, salaries at which appointments are made, etc., may be found in the Manual of Examinations revised to July 1, 1903.

## SCIENTIFIC NOTES AND NEWS.

DR. H. W. WILEY, chief of the Bureau of Chemistry, U. S. Department of Agriculture, has returned from Europe, where he has been studying the question of enforcing the law in regard to the exclusion of adulterated and falsely labeled food.

Professor H. S. Graves has returned from Europe where he has been making a study of the schools of forestry in Germany and Austria.

Dr. C. E. Beecher, professor of historical geology at Yale University, has during the summer been carrying on paleontological work in Canada, especially in the Lake St. John region of Quebec.

President Harper, of the University of Chicago, has returned to the United States. He has spent most of the summer in Turkey making arrangements for the proposed Babylonian explorations.

The Vienna Academy of Sciences has appointed a committee to study pitchblende, the substance from which radium is derived. Baron Auer von Welsbach, has placed his laboratories at the disposal of the committee.

Several members of the commission on London traffic, including Sir David Barbour and Baron Ribblesdale, have sailed for the United States to inquire into the street railway systems of New York and Boston.

The Emperor of Germany has conferred the title of *Wirklicher Geheimer Rath*, on Professor E. von Behring, the eminent pathologist.

Professor Frederick C. Clarke, head of the Department of Economics and Sociology of the Ohio State University, committed suicide on September 19.

Dr. Frank A. Hill, secretary of the Massachusetts State Board of Education, a trustee of the Massachusetts Institute of Technology, of the State Agricultural College at Albany and of the Boston Museum of Fine Arts, died on September 12, at the age of sixty-two years.

Professor Alexander Bain, for many years professor of logic in the University of Aberdeen, died on September 17, at the age of eighty-five years. Dr. Bain was the author of an important series of books on psychology, logic and English. His works on 'The Senses and the Intellect,' in 1855, and 'The Emotions and the Will,' in 1859, in many ways laid the foundations of modern scientific psychology.

The directors of the Dallas Commercial Club have called a national convention to be held in Dallas on October 8, to consider the boll weevil situation in the cotton growing districts. The attendance of delegates from all the cotton states and of representatives of the national Department of Agriculture is desired.

A press despatch from Berlin states that the imperial budget for 1904, now in preparation, allots $37,500 for combating typhus, which is specially virulent in Bavaria, Prussia and Alsace-Lorraine. The contamination of the rivers appears to be frequently the cause of the fever.

We learn from *Nature* that shortly before his death, the late Professor Nocard, of Paris, strongly urged the authorities of the Liverpool School of Tropical Medicine to make the institution available for the instruction of veterinary surgeons. A committee has now been formed for the purpose of giving effect to this suggestion, and the veterinary branch is open for the reception and instruction of students. It is under the direction of Professors Boyce and Sherrington, with adequate assistance, and a farm has been provided at Runcorn for its requirements.

*The Electrical World and Engineer* states that M. H. Duportal, the French inspector-général des Ponts et Chaussée, has selected St. Gervais as the starting point for the railway which, it is hoped, in a few years, will reach the summit of Mont Blanc. The project is identified with the name of M. Vallot, the director of the Mont Blanc Observatory, and is for a railway starting from Les Houches. The idea seems to be to get the shortest possible and most sheltered line, enabling the summit to be reached in all seasons; and it is conceded that M. Vallot's survey is the best possible for the purpose. M. Duportal's scheme does not supersede its predecessor, however; rather it will prepare the way for it; and it has the great merit of serving the immediate and practical necessities of the district. The first section of the proposed electric line reaches the Aiguille de Gouter almost direct from Fayet by way of the Bion-

nassay Valley, which faces full south, and consequently is always free from snow early in the year, at any rate as far as the Tête Rousse. An open-air line by this route is, therefore, feasible; and this is important, as tourists naturally desire to see the perspectives of the mountains, which would be impossible if the line should be tunneled all the way.

THE annual report for 1902 on the ice-conditions in the arctic seas has been issued by the Danish Meteorological Institute. According to the abstract in the *Geographical Journal*, information has come to hand in somewhat fuller measure than in the previous year. After a review of the state of the ice in the different seas around the polar area, the following general conclusions are arrived at. In 1902 the winter ice broke up very late, and the polar ice lay considerably nearer the northern coasts of Asia and Europe than in a normal year. The East Greenland current carried an abnormal quantity of pack-ice, though on the other hand an unusually small number of icebergs were carried from Greenland to the temperate seas, while the extent of polar ice in the northern branches of Baffin bay was smaller than in other recent years. The summer was rough and unsettled in all arctic and subarctic regions (with the partial exception of West Greenland), northerly and easterly winds predominating in the seas north of the Atlantic. These facts quite bear out the conclusions drawn from a consideration of the state of the ice in 1901, viz., that the accumulation of ice north of Spitzbergen caused by the prevailing westerly winds of that year would have an unfavorable influence on the state of the ice round Iceland and Greenland in 1902. Alike in the Barents sea, the region of Franz Josef Land, and around Spitzbergen, East Greenland, and Iceland the conditions were very unfavorable. The northeast, east, and southeast coasts of Spitzbergen were quite inaccessible through the summer; the pack-ice lay in a close broad belt off the coast of East Greenland, rendering access to the northern parts of the coast exceedingly difficult; while round Iceland the state of the ice was more unfavorable than ever since 1892.

## *UNIVERSITY AND EDUCATIONAL NEWS.*

A GIFT of another \$300,000 dormitory to the Sheffield Scientific School of Yale University by Mr. F. W. Vanderbilt, Yale, '76, of New York, is announced. About a year ago Mr. Vanderbilt gave a dormitory to the Sheffield Scientific School in memory of the late Cornelius Vanderbilt.

THE California Methodist Episcopal Conference has completed the work of raising an endowment fund of \$100,000 for the University of the Pacific.

BY the gift of a daughter of the late Charles Pratt of Brooklyn, the Department of Physical Education of Amherst College is to receive an additional annual income of \$1,500. Under the conditions of the gift, a graduate of the college may by a year or more of work in the theory and practise of physical education fit himself to become a teacher of that science, while assisting in the work of the department.

AFTER many delays the Pittsburg city councils have authorized the mayor to accept on behalf of the city the Flynn-Magee site purchased for the location of the Carnegie Technological School. The site includes thirty-two acres on the eastern border of Schenley Park.

WILLIAMS HALL, the new building to be devoted to the departments of geology and mechanical engineering at Lehigh University, will be formally opened on October 8, in connection with the twenty-fourth annual celebration of Founder's Day. Addresses will be delivered by Professor Edward H. Williams, Jr., of the department of geology and mining, who is the principal donor of the building, and by Dr. Rossiter W. Raymond, secretary of the American Institute of Mining Engineers.

BRIEFS have been filed opposing the application of the trustees of Rutgers College for the payment of \$80,000 allowed by the last New Jersey legislature in settlement of the claim of the college for back scholarships.

THERE has been incorporated in Quebec a school for the purpose of establishing and carrying on an agricultural school, and experimental farms. This school is to maintain

two or more schools and experimental farms in the Province of Quebec, one to be located in the district of Montreal and one in the district of Quebec. Each of the two schools is to contain accommodations for at least 50 pupils, who will be given a full course of three years' tuition, together with board, free of charge.

The Council for the Extension of Higher Education in North Staffordshire has approved plans for the proposed new college, including departments of instruction in mining and metallurgy, pottery, chemistry, and physics, and for administrative buildings, at an estimated cost of about $100,000.

Announcement is made that the first twelve students under the Rhodes scholarship will enter Oxford in October. Seven of the twelve will be from South Africa and five from Germany. They will be distributed in various colleges. It is stated that the conditions made by Mr. Rhodes in his will have been satisfactorily carried out and the men have been chosen, not only for their intellectual attainments, but for the qualities of character which Mr. Rhodes regarded as typical of the best manhood. The Americans and the remainder of the colonial scholars will not arrive at Oxford until 1904.

As we have already noted Dr. John H. Finley will be installed as president of the College of the City of New York on the morning of September 29, and the corner stone of the new building will be laid in the afternoon of the same day. The president will make an inaugural address, among others there will be addresses by Governor Odell, Mayor Low, Ex-president Cleveland and Presidents Butler of Columbia, Schurman of Cornell, Hadley of Yale and Remsen of Johns Hopkins.

Dr. N. M. Harris, of the Johns Hopkins Medical School, has accepted a position in the Bacteriological Laboratory of the University of Chicago.

Cornell University Medical College has provided for a chair of experimental pathology and bacteriology to carry on research work, at the Loomis Laboratory. Dr. Bertram H. Buxton is to be in charge, and will be assisted by Dr. Victor C. Vaughan, Jr.

Dr. Peter Potter, acting head of the department of anatomy in the University of Missouri, has accepted an associate professorship of anatomy in the Medical Department of St. Louis University.

The position in the Horticultural Department of Amherst Agricultural College, vacant by the resignation of Dr. G. A. Drew, has been filled by the appointment of Professor George O. Green of the Kansas Agricultural College.

At Williams College, Mr. Elmer I. Shepard, A.B. (Williams, 1900), has been appointed instructor of mathematics, and Mr. Brainerd Mears, A.B. (Williams, 1903), assistant in chemistry.

Appointments in the Chemical Department of the North Carolina College of Agriculture and Mechanic Arts, for the year 1903–4 have been made as follows: Wm. G. Morrison, M.A. (Virginia), instructor in chemistry; Robt. W. Page, B.S. (Columbia), instructor of analytic chemistry and metallurgy; Albert A. Haskell, B.S. (Massachusetts Institute of Technology), instructor in dyeing; O. M. Gardner, B.S. (North Carolina College of Agricultural and Mechanic Arts), instructor in chemistry.

The chair of physics and electrical engineering, at the Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y., has been filled by the appointment of Byron Briggs Brackett, A.B., A.M. (Syracuse), Ph.D. (Johns Hopkins).

Mr. John McFarlane, M.A. (Edinburgh and Cambridge), has been appointed lecturer in political and commercial geography in the Owens College, Manchester.

Dr. J. Tafel has been promoted to the professorship of chemistry and directorship of the laboratory at Würzburg, and Dr. W. Manchot, now docent at Göttingen, has been called to the associate professorship at Würzburg.